Claims 13 to 15 define stirrups according to the invention comprising two spiral elements.

Claim 16 defines a prefabricated load bearing element comprising a stirrup according to the invention, and claim 17 defines a method to use the stirrups for the reinforcement of walls.]

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will now be described by way of examples and with reference to the accompanying drawings in which:

Figures 1, 2, 2a present the known stirrups.

Figure 3 shows a stirrup according to the invention fastened to the principal reinforcement rods of a column and **figures 3a** shows schematically this stirrup.

Figures 4a, 4b, 4c, 4d, 4e show schematically stirrups according to the invention for the reinforcement of columns.

Figures 5, 5a, 5b, 5c, 6, 6a, 6b, 6c, 6d, 6e and 7, 7a present spiral stirrups having L, T and cross-shaped cross-sections respectively

Figures 8, 8a, 9 present spiral stirrups, adequate for footings or beams.

Figures 10, 10a present a spiral stirrup, adequate for a load-bearing wall.

Figures 11a, 11b, 11c, 11d, 11e, 11f show stirrups according to the invention for the reinforcement of load bearing elements having a Z-shaped cross section.

Figures 12 present a spiral stirrup with variable pitch.

Figure 13 shows a stirrup according to the invention consisting of two spiral elemets shown in **figures 13a and 13b**.

Figures 14a, 15a, 16a, 17a present a method of reinforcing load-bearing elements in accordance to the invention applied to the elements shown **in figures 14, 15, 16, and 17.**

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to the attached drawings we shall describe some indicative examples of the antiseismic spirals according to the invention. These are spiral stirrups usually manufactured by robot machines, from coiled rods of Φ4 to Φ16 in steel rolls of every quality and grade. The use of the coiled rods provides the possibility to produce the stirrup in the shape of a spiral with no discontinuation, in one piece of compound shape. They are manufactured compressed and they are stretched with relative convenience during their placing. Stirrups according to the invention may be also made of composite materials, for example from glass fibres.

Figure 3 shows a stirrup according to the invention. The spiral stirrup of this figure has consecutive alternating windings **7a** and **7b**. The set of windings **7a** forms a cage **5a** to house the principal rods **1a** of the reinforcement. In use the windings **7a** are tightened around the rods **1a** and it could be enough to fasten each winding even to three rods. Similarly the set of windings **7b** form a cage **5b** to house the principal rods **1b** of the reinforcement. Thus the stirrup includes two cages **5a, 5b,** whereby each one of the cages **5a, 5b** is formed by the alternating windings **7a, 7b** respectively. The projections of windings **7a** on a transverse plane coincide, so that the cage **5a** is cylindrical or approximately cylindrical. Similarly cage **5b** is cylindrical or approximately cylindrical, as the projection of the windings **7b** on a transverse plane coincide. In the case of the stirrup of **figure 4** the pitch is constant along the length of the stirrup, so that not only the projections of windings **7a** coincide,

but also the spatial shape of these windings is identical. The same applies for windings **7b**.

Figure 3a shows schematically a cross sectional view of the stirrup shown in **figure 3**, whereas **figures 4a, 4b, 4c, 4d, 4e** show cross sectional views of other stirrups to be used for the reinforcement of columns. The stirrup of **figure 4a** has two cages **5a, 5b** with overlapping cross sections, and **figure 4b** shows a stirrup with an almost rectangular cage **5b** within a polygonal cage **5a**. Such a stirrup may be formed with a circular or elliptical outer cage. Further stirrups for columns with rectangular cross-sections are shown in **figures 4c, 4d and 4e**.

Figures 5, 5a, 5b, 5c present spiral stirrups having L-shaped cross-sections comprising two (**see figure 5a**), three (**see figure 5b**) or four (**see figure 5c,** cages **5a, 5b, 5c, 5d**) cages. **Figures 6, 6a, 6b, 6c, 6d, 6e** present spiral stirrups with T-shaped cross sections, and **figures 7, 7a** a stirrup with a cross-head cross-section. T-shaped spiral stirrups, which are also used for the reinforcement of footings, have an excellent performance when they carry simultaneously shear, torsional and flexural loads.

Figure 8, 8a show a spiral stirrup to be used for the reinforcement of a beam or footing, with two overlapping cages **5a, 5b**, according the invention. With this arrangement a single spiral may be used for each footing or beam. **Figure 9** shows a spiral stirrup with three cages **5a, 5b, 5c** to be used for the reinforcement of a beam of a bridge.

Figure 10 shows the axonometric representation and plan view of a concrete shear wall with a spiral stirrup shown schematically in **figure 10a**.

Figures 11a, 11b, 11c, 11d, 11e, 11f show indicative representation of spirals for Z-shaped columns, which are often used at the corners of buildings.

With suitable programming of the production machine of the stirrup or appropriate fastening of the legs of the stirrup with the principal reinforcement rods, advancement of the windings along the length of the stirrup may be effected through longitudinal elements, while the windings remain at a substantial transverse plane. Such an option allows the use of the spirals in beam elements and footings that carry relatively high shear forces.

The pitch of the windings may be uniform or variable, as shown in **figure 12**. The variation in pitch may be effected either during production or during the reinforcing of the load-bearing element. With this arrangement the optimum economical solution arises because the variation of the pitch of the spiral may follow the shear forces diagram. **Figure 12** shows the spiral stirrup of **figure 3**, divided in parts with constant pitch. For example for a distance of 0,5 m in the base and 0,5 m in the top of the member the pitch equals to 10cm and 12 cm respectively, whereas along the middle portion of the stirrup, which extends along a length of 2 meters, the pitch is 20 cm. This arrangement results in a highly efficient solution, since it strengthens the "critical regions" of the load-bearing element with shorter winding spacing. The stirrup of **figure 12** may be used for the reinforcement of a column, beam or other structural elements.

The stirrup of the invention may be manufactured by a continuous extruded steel rod or by parts. With this arrangement the spiral is constructed by a number of spiral elements manufactured individually. The spiral elements may be constructed by rod with the same or different cross-section and may have the same or different pitch. In order to form the stirrup the spiral elements are placed side by side along their longitudinal direction and their ends are joint, so that one spiral element extends on one side of the joint and the other on the other side thereof. The joints may be effected in various ways: For example the two ends to be joint may be provided with hooks having an angle >= 135°, and one spiral element may be fastened to the other through these hooks. Alternatively each end of the spiral elements is provided with a winding having a very small or even zero pitch which are welded together to effect the

joint. Joint of the spiral elements may be also effected by the combination of the two previous arrangements. **Figure 13** shows a stirrup made of the two spiral elements **3', 3''**, shown schematically in **figures 13a, 13b**, which is to be used for the reinforcement of beams, columns or other structural elements. The joint of spiral elements to produce a spiral with the features of the invention may be effected in site or it may be prefabricated

Figures 14a, 15a, 16a, 17a show the application of spiral stirrups in accordance with the invention, for the reinforcement of the shear wall elements shown in **figures 14, 15, 16, and 17** respectively. The walls may be of large sizes and in general they may have a rectangular, angular, lift type etc. cross sections. In accordance with the method the combination of regular size spiral stirrups with longitudinal rods **4**, which may have hooks **6'** - 90° or 135° or other angle – at their ends effects the reinforcement of the walls. Other ways of attachment of the rods to the stirrups are also possible. Spiral stirrups are placed at shear walls ends and they tied or welded to the longitudinal rods, which in the case of te examples shown in the figures, are normal or almost normal to the longitudinal direction of the stirrups. Although particular advantages are offered by this method of reinforcing when applied in combination with the spiral stirrups of the invention, other spiral stirrups may be also used.

The stirrups of the invention may be used for the reinforcemnet of prefabricated load bearing structural elements.

[The embodiments of the invention described above are only examples of realisation of the invention and do not limit the extent of the protection sought.]

ANNEX I

a) Comparison of claims 1 to 17 as published in the International Publication with the claims 30 to 32 filed herewith.

b) Comparison of claims 18 and 19 as in the Annex of the International Examination Report with the claims 33 and 34 filed herewith.